Acoustic Beamforming for Signal Enhancement, Localization, and Separation

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Advances in Beamforming Concepts

Beamforming based on coherent processing of acoustic sensor data can be used to:

1. Enhance acoustic signal in known / unknown direction/position
2. Localize the acoustic source(s) in 2-D or 3-D
3. Blindly separate different acoustic sources due to their spatial separations and not their frequency characteristics

Practical Implementation of Acoustic Beamforming Techniques

We have conducted research in these directions:

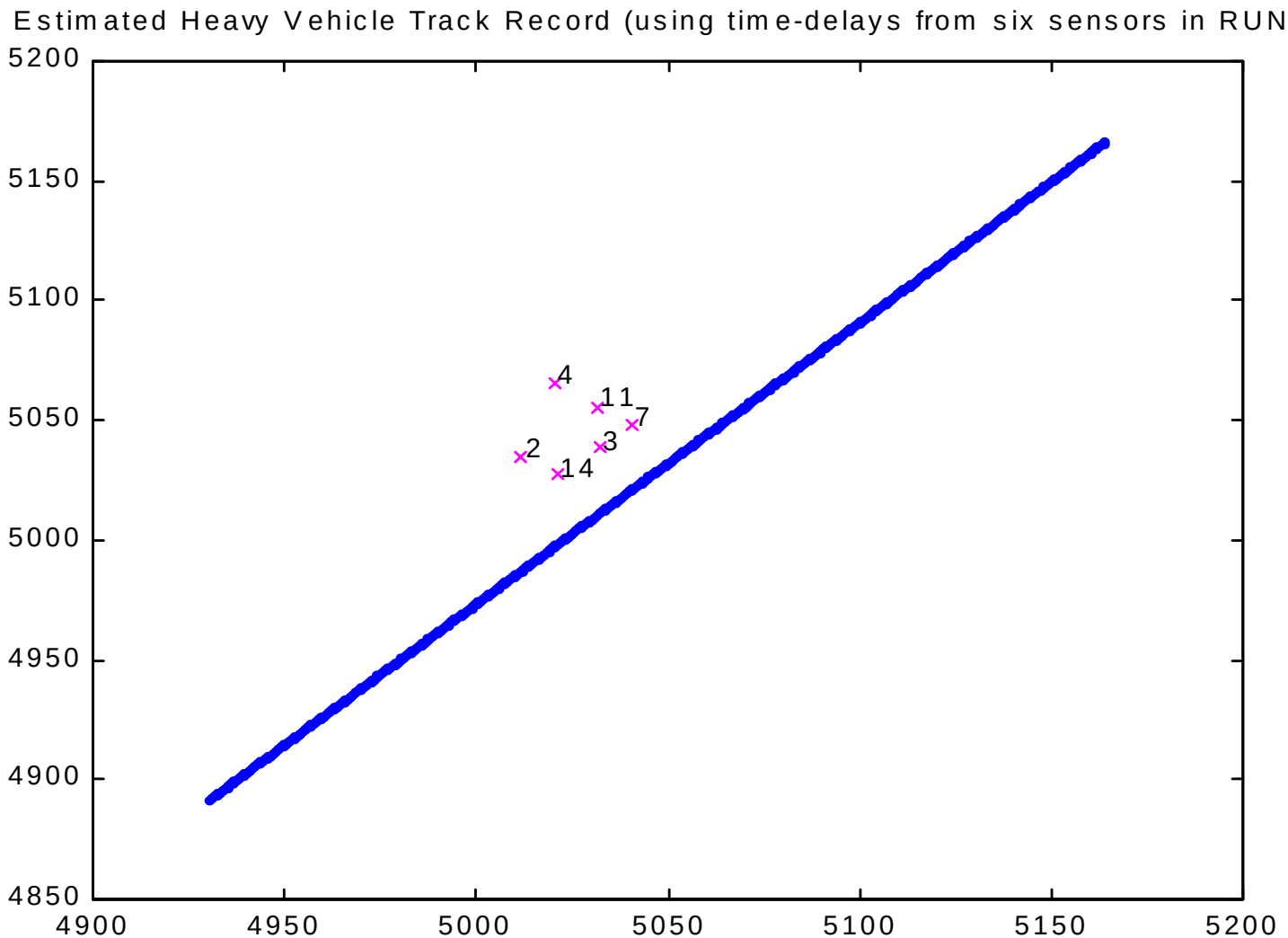
1. Steerable microphone array to enhance speaker/ reject interferers(s) for hearing aid appl. (HEI)
2. Blind beamforming of randomly placed sensors for enhanced detection/classification; localization/tracking of vehicles/foot steps (DARPA/ATO AWAIRS project with RSC)
3. Blind separation of two (or more) speakers using subspace blind deconvolution/decorrelation

Microphone Array for Hearing Aid App.

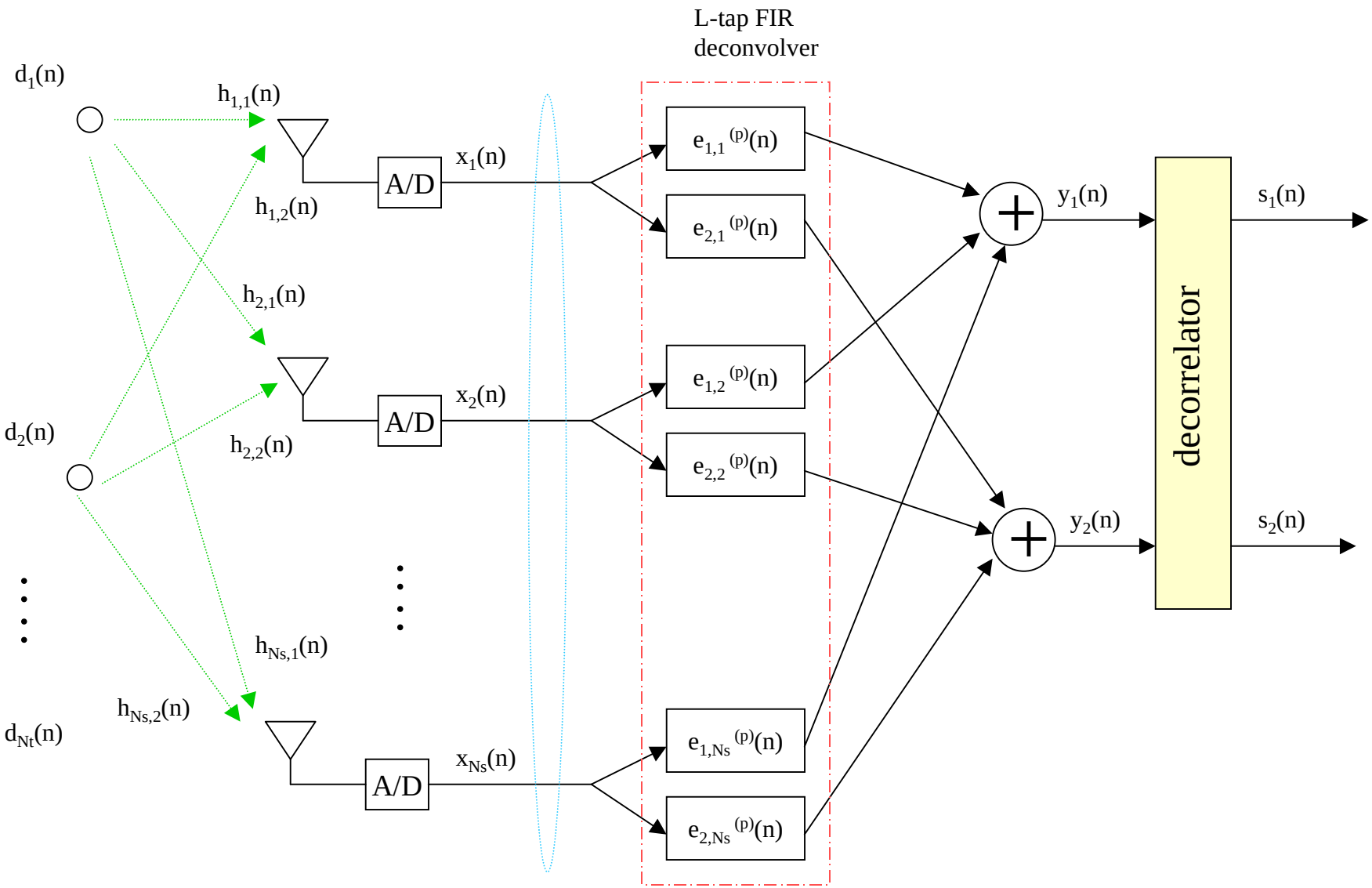
- Use four microphones in a linearly array with about 2.2 cm inter-sensor separation
- Use “maximum power”criterion beamformer to steer mainlobe toward desired speaker and nulls toward interferers

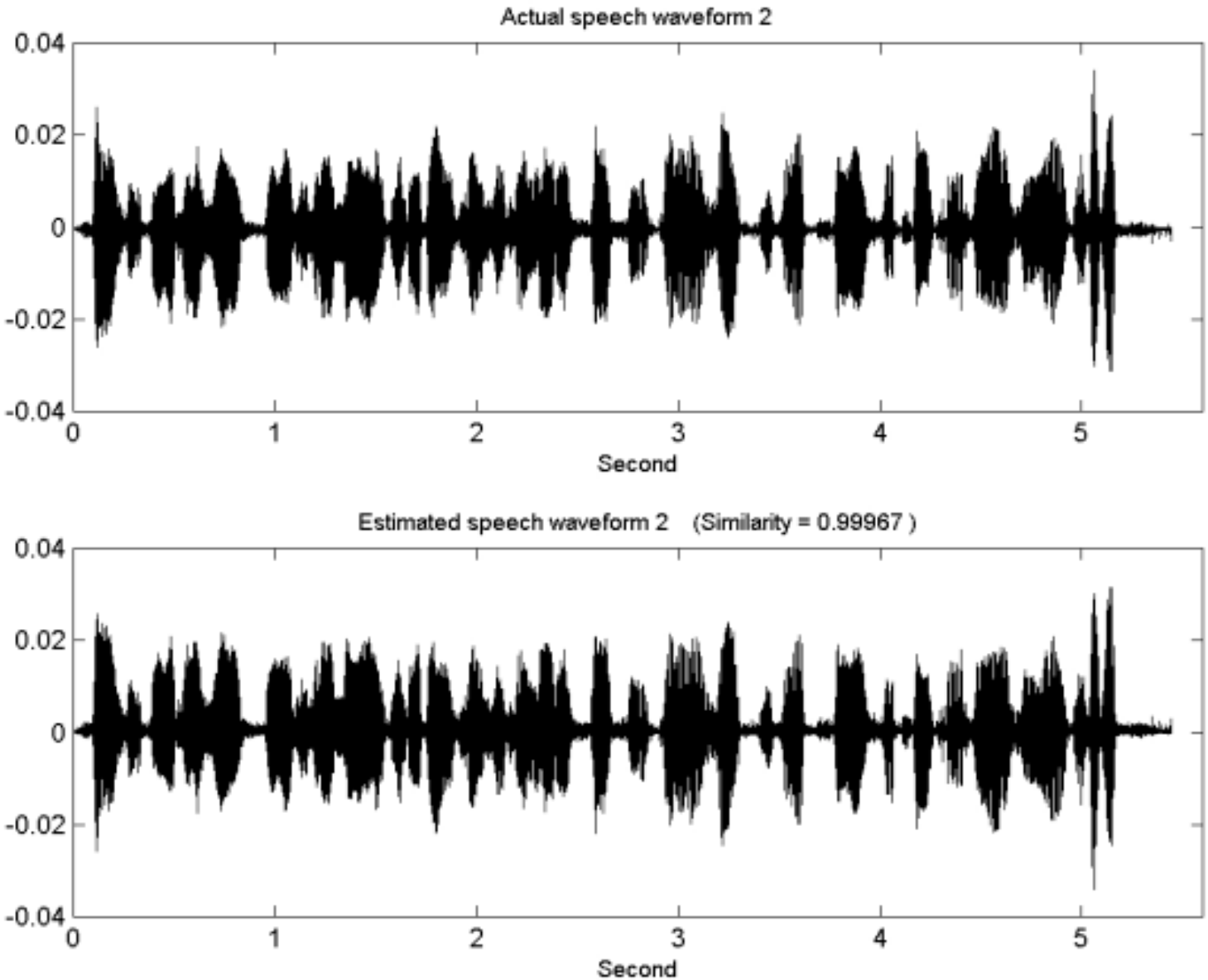
Case	Source/Angle	Interfer/Angle	SIR(dB)	ΔSNR(db)Meas.	
1	Speech/0	Speech/-45	0	0	No processing
2	Speech/0	Speech/-45	0	22	Free space
3	Speech/0	Speech/-45	0	12	Low-rev.
4	Speech/0	C.noise/-45	-10	0	No processing
5	Speech/0	C.noise/-45	-10	21	Free space
6	Speech/0	C.noise/-45	-10	12	Low-rev.

Estimation of a Heavy Track Vehicle Using An AWAIRS Blind Beamforming Algorithm



Blind Source Separator System




Actual speech waveform 2
0.04
0.02
0
-0.02
-0.04
0
1
2
3
4
5
Second
Estimated speech waveform 2 (Similarity = 0.99967)
0.04
0.02
0
-0.02
-0.04
0
1
2
3
4
5
Second